EFFECT OF PLANTING DATE ON ACCUMULATED GROWING DEGREE UNITS, GRAIN YIELD AND THREE GROWTH TRAITS OF 16 EGYPTIAN YELLOW MAIZE INBRED LINES

ABSTRACT

An experiment was carried out in 2021 at three agriculture research stations i.e. Gemmeiza, Ismaelia and Sids, Egypt. The objective was to test the effect of 3 planting dates i.e. April 20th (early), May20th (optimal) and June 20th (moderately late) on number of days to 50% tasselling and silking, plant height and grain yield of 16 Egyptian yellow maize inbred lines. In addition, to calculate accumulated growing degree units (GDU) from planting to 50% silking. A randomized complete block design with 4 replications was used. Results revealed highly significant differences among tested inbreds for all studied traits at the three planting dates indicating the presence of genetic diversity among tested inbreds. Also, the same trend was found for differences among locations and inbreds x location indicating climatic variability among the three testing locations and that inbreds behaved differently at different locations due to differences in climatic conditions among locations and also genetic diversity among inbreds. Number of days to 50% tasselling and silking was reduced from April to June planting as a result of increased temperatures during plant development. Longest plant heights were obtained in April planting as a result of prolonged vegetative growth due to cool - moderate temperatures prevailing at early vegetative growth. Grain yield of all tested inbreds was reduced, with few exceptions, in June 20th planting as a result of high temperatures prevailing at time of tasselling and silking which resulted in pollen, stigma or fertilization abortion and caused poor seed setting. Calculation of accumulated growing degree units for tested inbreds revealed big variation among them as a result of genetic diversity of inbreds and matched well with variation present in their silking dates. Results of GDU would help in expectation of timing for many agricultural practices such beginning of detasselling process and harvest in hybrid breeding programs

Key words: maize, inbred lines, agronomic traits and growing degree units (GDU).

INTRODUCTION

Maize is considered as one of the most grain strategic crops around the world. In Egypt, it comes second after wheat in terms of economic importance and production. For maximum production of each hybrid, it is important to decide its optimum planting date. In hybrid seed production programs, it is also crucial to decide the appropriate sowing date of parental inbreds across different times during the season to obtain good ear seed setting. **El-mekser *et al.* (2012)** working on inbred lines, found that relatively late planting date (June 15th) produced the lower grain yield and reduced plant and ear heights. Climatic changes associated with different planting dates (sunshine, temperature etc.) have a modifying effect on growth and development of maize plants (**Sarvari and Futo, 2000**). They stated also that, late planting tremendously affected grain yield and early and mid-season planting are recommended for high yield. This is why testing of inbreds across different sowing dates is of great importance in hybrid breeding programs. **Varma *et.al*. (2014)** stated that early and mid-early sowings in India resulted in good yields and high quality seeds**. Liaqat *et al*. 2018** stated that planting dates significantly affected silking date, plant height and grain yield. Maize growth and development stages are normally sensitive and are affected by various weather parameters as affected by planting dates (**Shrestha, *et. al.,* 2018).**

As an effect of delayed planting (off-season planting), **Gouda *et al*. (1998)** studied effect of different planting times on yield and some agronomic traits of some maize hybrids. They found that delayed planting affected all studied agronomic traits in addition to a noticeable yield reduction. A similar trend was found by **Hassan (1999)** where he found that late planting date significantly decreased flowering dates, plant and ear height and grain yield.

Dalpo and Albert (2017) found that late planting date negatively affected plant physiological growth and grain yield of maize and could have a considerable risk on maize growers. **Jiban *et al.* (2018)** stated that delayed planting dates affected anthesis and silking, photosynthesis, physiological maturity and dry matter production and consequently reduced grain yield.

For maize, **Marton *et al.,* 2004** stated that growth development is strongly related to the accumulation of heat or temperature units above a threshold or base temperature below which little growth occurs. Scientists have determined the lower base temperature for maize is 10 ^{0}C. In maize, there is also an upper threshold (30 ^{0}C) above which little or no growth occurs. However, subtropical and tropical maize varieties can grow in temperatures above 30 C^0 **(Khalifa 2019).** Growing degree units (GDU) information is used to help in planning crop management decisions such as detasselling process time and harvest time. **Hassan (2017)** classified some Hungarian maize hybrids, under Egyptian conditions, into different maturity groups using accumulated heat units (HU) method and found that different maturity groups behaved differently for many agronomic traits. In a bulletin by **AsgrowDekalb (2018)** extension department, they stated that a corn plant requires a certain number of growing degree units (GDU,s) to reach maturity regardless of the number of calendar days it takes to accumulate. They also mentioned that, the relationship of GDU accumulation and corn development can help predict when important growth stage will occur.

Growing degree units (GDU) are used to measure corn growth relative to temperature and each corn hybrid can be identified with a GDU number that indicates GDU,s needed to reach certain growth stage and black layer formation. They added also that, growing degree days (GDD,s) and GDU,s refer to the same formula and can be used interchangeably (**AsgrowDekalb, 2020**).

The objectives of this study are 1: study the effect of 3 planting dates on tasselling and silking dates, plant height and grain yield, 2. Calculate accumulated growing degree units (GDU) for tested inbreds from planting date to 50% silking.

MATERIAL AND METHODS

Sixteen yellow maize inbred lines with different genetic backgrounds (Table 1) were used in this investigation to study the effect of three planting dates i.e. April 20th (early), May 20th (optimal date) and June 20th (moderately late) on number of days to 50% tesselling and silking, plant height (cm) and grain yield (ton/ha.) and also to calculate accumulated growing degree "units (GDU) from planting date to 50% silking. Trials were conducted at Gemmeiza (30^0 47' W), Ismaelia (30^0 36' E) and Sids (30^0 95$^{'}$ E) agriculture research stations, ARC, Egypt. A randomized complete block design with 4 replications was used. Experimental plot size consisted of one row of 6 m in length and 70 cm row spacing was used. All recommended cultural practices were applied. Data for 50% tasselling and silking were scored. Average plant height was measured on 5 guarded plants/plot. At maturity, ears were harvested, weighed and seed moisture content was measured. Grain yield was adjusted to 15.5% moisture. After which, yield/plot was converted to ton/ha.

Maize growing degree units (GDU) are calculated by subtracting maize lower base or threshold temperature (10 ^{0}C) from the average daily temperature in ^{0}C. Average daily air temperature is calculated by averaging the daily maximum and minimum air temperatures. Accumulated GDU are scored starting from planting date to the day where 50% silking was reached (**AsgrowDekalb Bulletin. 2018, 2020 and Monsanto 2015**). Daily GDU can be calculated as follow:

Daily maize GDU (^{0}C) = $T_{max} + T_{min} / 2 - T_{base}$

Where, T_{max} and T_{min} are maximum and minimum day air temperatures, while T_{base} is the base temperature (10 ^{0}C) for maize growing.

Trials data were statistically analyzed using SAS statistical analysis program **(SAS Institute, 2000).** Comparison of means was achieved according to **Steel and Torrie (1980).** Combined analysis for each trait across locations for each planting date was achieved

Table 1: Origin of the 16 inbred lines involved in the study.

No.	Inbred	Origin
1	Sakha- 1	Local x subtropical germplasm
2	Sakha- 2	Local x subtropical germplasm
3	Sakha- 3	Local x subtropical germplasm
4	Sakha- 4	Local x subtropical germplasm
5	Sakha- 10	Local x subtropical germplasm
6	Sakha- 11	Local x subtropical germplasm
7	Giza-639	**American** - **Temperate** germplasm
8	Giza- 653	**Subtropical** germplasm. **CIMMYT _ Mexico**
9	Giza- 656	**American** - **Temperate** Germplasm
10	Giza- 657	**American -Temperate** Germplasm
11	Giza- 658	**American -Temperate** Germplasm
12	Giza- 666	**American -Temperate** germplasm
13	Gemmeiza- 1002	**Subtropical** DMR population, **Nigeria**
14	Gemmeiza- 1004	**Subtropical** germplasm – **IITA – Nigeria**
15	Gemmeiza- 1021	**Local** population developed from the **subtropical** cross (Sd.121x DMR – ESR).

16	Sids- 3120	Population 45- **Local – Egypt**

Results and discussion

Analysis of variance

Analysis of variance for all studied traits is illustrated in Tables 2-5. Results revealed highly significant differences among inbred lines, locations and inbred x location (IxL) interaction. These results indicated real genetic differences among tested inbred lines and also climatic differences among testing locations. In addition, significant IxL interaction indicated that inbreds behaved differently at different locations as a result of different climatic conditions at testing locations.

Table 2: Mean squares for number of days to 50% anthesis under three planting dates of 16 yellow maize inbred lines across three locations.

Source of variation	Df	MS		
		April 20th	May 20th	June 20th
Location (L)	2	892.94**	24.54**	79.89**
Rep/L	9	2.20	5.78	2.71
Inbred Lines (I)	15	87.43**	77.65**	44.21**
I×L	30	11.38**	6.88**	15.62**
Error	135	3.08	1.33	2.60

Table 3: Mean squares for number of days to 50% silking under three planting dates of 16 yellow maize inbred lines across three locations.

Source of variation	Df	MS		
		April 20th	May 20th	June 20th
Location (L)	2	1005.81**	43.15**	125.77**
Rep/L	9	2.48	7.84	2.35
Inbred Lines (I)	15	92.48**	78.01**	41.34**
I×L	30	10.97**	4.87**	15.05**
Error	135	3.42	1.67	4.11

Table 4: Mean squares for plant height under three planting dates of 16 yellow maize inbred lines across three locations.

Source of variation	Df	MS		
		April 20th	May 20th	June 20th
Location (L)	2	22614.19**	5925.52**	15246.22**
Rep/L	9	334.16	189.58	145.79
Inbred Lines (I)	15	2497.63**	2855.97**	2957.70**

I×L	**30**	**1297.94****	**487.33****	**1001.50****
Error	**135**	**84.07**	**138.38**	**81.25**

Table 5: Mean squares for grain yield under three planting dates of 16 yellow maize inbred lines across three locations.

Source of variation	**Df**	**MS**		
		April 20th	**May 20th**	**June 20th**
Location (L)	**2**	**17.90****	**103.29****	**60.57****
Rep/L	**9**	**0.13**	**0.19**	**0.11**
Inbred Lines (I)	**15**	**6.36****	**3.92****	**1.31****
I×L	**30**	**2.17****	**1.40****	**0.61****
Error	**135**	**0.07**	**0.08**	**0.03**

Days to 50% tasselling and silking

Results for average number of days to 50% tasselling and silking are shown in Tables 6 and 7. Results revealed highly significant differences for both traits among the 3 planting dates. As a result of climatic differences among locations, inbreds behaved differently from one planting date to another. At Gemmeiza station (Mid-delta), where weather in April is relatively cool, the early vegetative growth was slow which illustrates longer time that plants took to reach both tasselling and silking. Difference between April (early) and May planting (optimal) for both traits reached 10 and 9 days, respectively and only one day difference was obtained for both traits when moving from May planting to June planting (moderately late) at the same station. For Ismaelia station (west- delta) where weather temperature is moderate in April and warmer in May and June (32-36 ^{0}C), differences for both traits among the 3 planting times was reduced to 4 days only. For Sids station (mid-south delta) where high temperature are prevailing starting from late April up to September, no significant differences (only one day) were found among the 3 planting dates for both traits, but plants reached tasselling and silking earlier than April planting. However, inbreds behaved differently with increasing temperatures in mid-summer where some inbreds were affected more than others. This information is very important in hybrid seed production programs to adjust planting time of parental inbreds of each hybrid. **El-Mekser *et al*. (2012)** found that late planting (beyond June) of inbreds reduced number of days to anthesis and silking. Same results were reached by **Liaqat *et al*. (2018) Gouda *et al*. (1998)**; **Jiban *et al*. (2018) and Hassan (1999).**

Plant Height

Average plant height for the 16 inbred lines in each location and planting date was illustrated in Table 8. Significant differences in plant height were found among inbreds and also among planting dates. In the 3 research stations, cool to moderate temperatures in April extended vegetative growth in early period of plant development which resulted in taller plant height in April planting as compared to May and June planting except, unexpectedly, at Gemmeiza station for unknown reasons. Reduction in plant height as a result of warming up in May reached 12 and 27 cm at Ismaelia and Sids research stations, respectively. At Sids station, temperatures are normally high (above 40 ^{0}C) during June- August which accelerated plant growth and reduced plant height compared to April and May planting except inbreds Sk. 4 and Gz. 666 where they were not affected and were slightly taller than May planting. This is can be interpreted on the basis of their genetic background and its response to climatic conditions. Many researchers reached same results (**Hassan 1999**, **El-Mekser *et al*., 2012; Sarvari and Futo, 2000; Gouda *et al*., 1998 and Dalpo and Albert, 2017.**

Grain yield

Grain yield averages for the studied inbreds at each location and each planting date are shown in Table 9. Highly significant differences were found among inbreds at each location, among locations and also among planting dates. Results revealed that the highest average grain yield for all studied inbreds was obtained at Gemmeiza research station on May 20th and April 20th i.e. 3.50 and 3.03 t/ha., respectively, followed by Sids stn. (2.42 t/ha.) on April 20th planting date. In addition, Gemmeiza stn. produced the highest inbreds average grain yield across the 3 planting dates (3.27 t/ha.) followed by Ismaelia stn. (1.99 t/ha.), then Sids stn. (1.28 t/ha.). So, it is recommended for seed production purposes of these inbreds to be at Gemmeiza stn. on May and April planting dates or at Sids stn. On April 20th. The reduction in yield of inbreds at Ismaelia and Sids stns. in May and June planting is mainly due to higher air temperatures specially June planting at Sids where temperature that are prevailing at flowering time are so high (above 40 ^{0}C) and caused poor seed setting due to pollen or fertilization abortion. **Jiban *et al*. 2018** showed that delayed planting affected grain yield and flowering dates. Also, **Sarvari and Futo, 2000** stated that weather conditions associated with late planting affected growth stages and d grain yield. **Gouda *et al*. 1998** and **Varma *et al*. 2014** reached similar results.

Table 6: Effect of planting date on number of days to 50% anthesis of 16 yellow maize inbred lines evaluated at 3 locations in 2021.

Inbred line	Gemmeiza			Ismailia			Sids		
	April 20th	May 20th	June 20th	April 20th	May 20th	June 20th	April 20th	May 20th	June 20th
Sk1	76.25	63.50	63.25	72.25	66.00	63.50	65.75	68.00	67.50
Sk2	74.75	64.75	65.00	71.00	65.75	62.50	68.75	67.75	71.50
Sk3	74.75	65.00	65.00	65.25	65.50	61.50	67.25	65.75	64.25
Sk4	76.50	64.75	65.00	70.50	65.00	65.00	67.75	67.00	64.75
Sk10	73.50	63.75	64.25	67.50	64.75	61.25	64.75	63.75	65.25
Sk11	72.50	64.75	64.50	68.50	63.25	62.25	64.75	65.00	63.25
Gz 639	75.75	68.25	65.25	72.00	70.00	65.50	69.25	69.50	70.00
Gz 653	85.00	72.00	66.50	78.00	70.00	66.00	71.75	71.75	70.25
Gz 656	75.75	68.25	67.75	72.75	70.50	67.25	69.00	66.75	67.75
Gz 657	79.75	70.00	63.00	75.75	71.50	66.25	72.00	72.00	69.75
Gz 658	73.75	68.00	64.25	71.75	69.25	63.25	69.00	65.25	68.00
Gm 1002	71.00	64.50	64.00	71.25	67.00	61.25	67.00	64.75	60.25
Gm 1004	76.50	65.00	65.25	71.25	69.00	65.25	68.25	66.50	64.25
Gm 1021	71.25	64.00	65.00	71.25	65.50	63.25	67.75	63.75	64.75
Sd 3120	73.50	63.75	64.50	71.00	66.50	62.50	67.25	66.00	64.00
Gz 666	71.25	62.50	63.00	69.75	63.00	61.50	62.00	60.50	58.25
Average	75.11	65.80	64.72	71.23	67.03	63.63	67.64	66.50	65.86
LSD 0.05	0.86	1.13	1.19	0.83	0.57	0.87	4.16	2.55	3.70

Table 7: Effect of planting date on number of days to 50% silking of 16 yellow maize inbred lines evaluated at 3 locations in 2021.

Inbred line	Gemmeiza			Ismailia			Sids		
	April 20th	May 20th	June 20th	April 20th	May 20th	June 20th	April 20th	May 20th	June 20th
Sk1	78.25	65.00	65.25	74.25	68.25	65.50	66.75	68.25	70.00
Sk2	76.00	66.25	67.00	73.25	68.00	65.25	69.75	68.00	74.50
Sk3	75.75	67.00	67.00	68.25	67.75	64.25	68.50	67.75	66.00
Sk4	78.50	66.75	67.00	72.75	67.00	67.25	68.50	68.00	70.00
Sk10	74.75	65.75	66.25	69.50	67.25	63.75	66.00	64.75	66.75

Sk11	**74.50**	**66.50**	**66.50**	**71.00**	**65.75**	**64.75**	**65.75**	**65.00**	**64.50**
Gz 639	**78.25**	**70.00**	**67.25**	**74.00**	**72.00**	**67.25**	**71.00**	**70.25**	**73.50**
Gz 653	**87.00**	**74.00**	**68.50**	**80.00**	**71.75**	**67.75**	**73.25**	**73.25**	**71.50**
Gz 656	**77.25**	**70.25**	**69.75**	**74.75**	**73.00**	**69.00**	**70.00**	**69.50**	**69.50**
Gz 657	**81.75**	**72.00**	**65.50**	**77.75**	**73.25**	**67.50**	**74.00**	**73.25**	**73.50**
Gz 658	**76.75**	**69.75**	**66.25**	**73.75**	**71.00**	**65.25**	**70.75**	**69.00**	**69.00**
Gm 1002	**72.25**	**66.50**	**66.00**	**73.50**	**69.00**	**63.50**	**68.50**	**65.25**	**61.50**
Gm 1004	**78.25**	**67.00**	**67.25**	**73.50**	**71.25**	**67.75**	**70.25**	**69.00**	**67.75**
Gm 1021	**72.75**	**66.00**	**67.00**	**73.50**	**68.00**	**65.25**	**68.75**	**64.50**	**67.00**
Sd 3120	**75.50**	**65.50**	**66.75**	**73.25**	**68.75**	**64.75**	**68.00**	**67.25**	**68.25**
Gz 666	**72.50**	**63.75**	**65.00**	**72.00**	**65.00**	**63.75**	**63.75**	**64.50**	**63.50**
Average	**76.88**	**67.63**	**66.77**	**73.44**	**69.19**	**65.78**	**68.97**	**67.97**	**68.55**
LSD 0.05	**1.02**	**1.16**	**1.27**	**1.04**	**1.01**	**1.02**	**4.32**	**2.80**	**4.73**

Table 8: Effect of planting date on plant height of 16 yellow maize inbred lines evaluated at 3 locations in 2021.

Inbred line	**Gemmeiza**			**Ismailia**			**Sids**		
	April 20th	**May 20th**	**June 20th**	**April 20th**	**May 20th**	**June 20th**	**April 20th**	**May 20th**	**June 20th**
Sk1	**197.50**	**185.00**	**185.00**	**172.50**	**198.75**	**216.25**	**220.00**	**198.75**	**173.75**
Sk2	**135.00**	**142.50**	**150.00**	**160.00**	**167.50**	**156.25**	**161.25**	**137.50**	**125.00**
Sk3	**156.25**	**161.25**	**165.00**	**167.50**	**176.25**	**177.50**	**175.00**	**136.25**	**131.25**
Sk4	**158.75**	**190.00**	**172.50**	**197.50**	**192.50**	**201.25**	**220.00**	**188.75**	**193.75**
Sk10	**190.00**	**157.50**	**153.75**	**175.00**	**163.75**	**192.50**	**167.50**	**145.00**	**131.25**
Sk11	**160.00**	**180.00**	**158.75**	**242.50**	**211.25**	**200.00**	**201.25**	**175.00**	**146.25**
Gz 639	**167.50**	**152.50**	**182.50**	**167.50**	**185.00**	**201.25**	**170.00**	**153.75**	**145.00**
Gz 653	**161.25**	**162.50**	**152.50**	**200.00**	**177.50**	**201.25**	**207.50**	**188.75**	**148.75**
Gz 656	**150.00**	**160.00**	**162.50**	**202.50**	**171.25**	**167.50**	**191.25**	**145.00**	**151.25**
Gz 657	**135.00**	**138.75**	**141.25**	**195.00**	**165.00**	**158.75**	**171.25**	**122.50**	**101.25**
Gz 658	**138.75**	**160.00**	**161.25**	**176.25**	**170.00**	**180.00**	**187.50**	**146.25**	**143.75**
Gm 1002	**127.50**	**158.75**	**162.50**	**170.00**	**177.50**	**188.75**	**195.00**	**178.75**	**166.25**
Gm 1004	**135.00**	**151.25**	**173.75**	**178.75**	**153.75**	**116.25**	**146.25**	**135.00**	**130.00**
Gm 1021	**137.50**	**166.25**	**151.25**	**208.75**	**161.25**	**162.50**	**187.50**	**166.25**	**160.00**

Sd 3120	**155.00**	**158.75**	**165.00**	**187.50**	**165.00**	**155.00**	**170.00**	**165.00**	**153.75**
Gz 666	**156.25**	**177.50**	**165.00**	**206.25**	**183.75**	**163.75**	**181.25**	**140.00**	**143.75**
Average	**153.83**	**162.66**	**162.66**	**187.97**	**176.25**	**177.42**	**184.53**	**157.66**	**146.56**
LSD 0.05	**9.23**	**12.38**	**11.73**	**15.80**	**15.84**	**15.39**	**13.30**	**20.93**	**10.95**

Table 9: Effect of planting date on grain yield (t./ha.) of 16 yellow maize inbred lines evaluated at 3 locations in 2021.

Inbred line	**Gemmeiza**			**Ismailia**			**Sids**		
	April 20th	**May 20th**	**June 20th**	**April 20th**	**May 20th**	**June 20th**	**April 20th**	**May 20th**	**June 20th**
Sk1	**3.12**	**4.31**	**1.33**	**2.14**	**2.10**	**2.84**	**3.62**	**1.07**	**0.18**
Sk2	**3.66**	**4.00**	**1.12**	**2.06**	**2.34**	**2.34**	**2.14**	**1.67**	**0.32**
Sk3	**3.83**	**4.29**	**1.86**	**1.94**	**2.31**	**3.27**	**3.56**	**1.75**	**0.92**
Sk4	**3.73**	**3.91**	**0.92**	**1.81**	**1.75**	**2.62**	**2.81**	**0.82**	**0.24**
Sk10	**2.06**	**2.27**	**1.11**	**1.83**	**1.49**	**1.82**	**2.70**	**0.83**	**0.20**
Sk11	**3.62**	**3.87**	**2.35**	**2.50**	**1.28**	**2.62**	**4.03**	**1.24**	**0.31**
Gz 639	**3.96**	**4.03**	**2.01**	**2.34**	**2.16**	**2.71**	**1.82**	**0.94**	**0.41**
Gz 653	**2.30**	**1.92**	**0.85**	**1.27**	**1.68**	**2.29**	**0.07**	**0.08**	**0.63**
Gz 656	**2.79**	**3.62**	**1.37**	**2.55**	**1.77**	**3.12**	**1.34**	**0.51**	**0.28**
Gz 657	**0.78**	**0.54**	**1.25**	**1.85**	**1.08**	**2.26**	**0.10**	**0.03**	**0.07**
Gz 658	**1.40**	**4.21**	**0.90**	**1.53**	**1.37**	**2.51**	**1.39**	**1.02**	**0.47**
Gm 1002	**3.40**	**3.81**	**0.85**	**1.64**	**2.09**	**1.60**	**2.60**	**0.62**	**0.07**
Gm 1004	**3.53**	**3.98**	**0.86**	**2.59**	**1.40**	**1.83**	**1.83**	**0.96**	**0.28**
Gm 1021	**3.80**	**4.20**	**0.81**	**1.78**	**1.40**	**1.48**	**4.00**	**2.22**	**0.18**
Sd 3120	**3.23**	**3.45**	**0.99**	**1.65**	**1.38**	**1.95**	**2.69**	**2.31**	**0.90**
Gz 666	**3.32**	**3.66**	**1.95**	**2.18**	**1.47**	**1.45**	**4.08**	**0.81**	**0.12**
Average	**3.03**	**3.50**	**1.28**	**1.98**	**1.69**	**2.29**	**2.42**	**1.05**	**0.35**
LSD 0.05	**0.40**	**0.50**	**0.21**	**0.35**	**0.37**	**0.34**	**0.39**	**0.31**	**0.14**

Growing Degree Units (GDU)

Accumulated growing degree for each inbred at each planting date was calculated and shown in Table 10 according to the formula described by **AsgrowDekalb Bulletin 2018, 2020**. Also, average GDU,s for each inbred across the three testing locations at each planting date was calculated and shown in the same table. Variation in results of different inbreds reflected actual variation in silking dates of tested inbreds. GDU,s for each inbred supposed to be the same regardless of planting time. However, in this investigation it was found that DDU,s of each inbred increased when moving from planting date April 20th to June 20th i.e. with increasing seasonal temperature. This could be due to effect of other environmental factors such as soil temperature, day length and light intensity that affected growth development of plants and resulted in variation observed in GDU,s of inbreds in this investigation. **Marakinyo *et al*., 2011** indicated the usefulness of GDU,s to classify maize genotypes into maturity groups.

Conclusion

Results of this investigation indicated that different planting dates (early, optimal and late) across maize growing season significantly affected growth traits of maize inbreds such tasselling and silking dates, plant height and grain yield due to varying temperatures prevailing at each planting date. In addition, determination of accumulated growing degree units for different growth stages of investigated inbred lines would help in planning and performing of many processes during the growing season.

Table 10: Accumulated growing degree units (GDU) for number of days to 50% silking of 16 yellow maize inbred lines grown at 3 planting dates and 3 location in 2021.

Inbred line	April 20th				May 20th				June 20th			
	Gm	**Ism**	**Sd**	**Avg.**	**Gm**	**Ism**	**Sd**	**Avg.**	**Gm**	**Ism**	**Sd**	**Avg.**
Sk1	1000	980	910	**963**	991	1041	1132	**1055**	1075	1183	1280	**1179**
Sk2	970	1115	955	**1013**	1009	1060	1138	**1069**	1101	1156	1211	**1156**
Sk3	970	1005	930	**968**	1025	1077	1130	**1077**	1101	1156	1219	**1159**
Sk4	1015	1005	930	**983**	1025	1077	1138	**1080**	1101	1156	1285	**1181**
Sk10	954	955	895	**935**	1008	1058	1180	**1082**	1092	1201	1250	**1181**
Sk11	955	950	885	**930**	1025	1080	1083	**1063**	1095	1204	1195	**1165**
Gz 639	1000	1135	1010	**1048**	1078	1132	1165	**1125**	1109	1165	1220	**1165**
Gz 653	1155	1140	1085	**1127**	1143	1200	1220	**1188**	1135	1249	1302	**1230**
Gz 656	985	1030	980	**998**	1078	1132	1180	**1130**	1151	1266	1272	**1230**
Gz 657	1070	1195	1050	**1105**	1110	1165	1185	**1153**	1080	1188	1224	**1164**
Gz 658	985	1035	985	**1002**	1078	1132	1156	**1122**	1092	1202	1266	**1187**
Gm1002	900	1015	980	**965**	1026	1077	1101	**1068**	1086	1195	1139	**1140**

Gm1004	1000	915	870	**928**	1026	1077	1156	**1086**	1109	1220	1235	**1188**
Gm1021	915	1005	930	**950**	1009	1060	1066	**1045**	1101	1211	1203	**1172**
Sd 3120	970	995	930	**965**	1008	1055	1135	**1066**	1095	1205	1250	**1183**
Gz 666	915	890	835	**880**	975	1024	1072	**1024**	1070	1177	1139	**1129**

REFRENCES

AsgrowDekalb. 2018. Growing degree units and corn growth. Agronomy advice – research bulletin.

AsgrowDekalb. 2020. Corn growth stages and growing degree units. In: AgKnowledge spotlight.1/8-8/8.

Dalpo Bola Akinnoye-adelabo and Albert Thembinkosi Modi. 2017. Planting dates and harvesting stages influence on maize yield under rain-fed conditions. J. Agric. Sci. 9(9): 43-55.

El-Mekser, H.Kh.A. M.M.A. Osman and M.B.A. Elkoomy. 2012. Performance of some commercial inbred lines of maize under different planting dates. Egypt. J. Agric. Res. 90(4): 267-273.

Gouda, A.Sh..; M.A. Sultan and F.A. El-Zeir. 1998. Response of some newly released white and yellow maize hybrids to planting dates. J. Agric. Sci. Mansoura Univ., 23(3): 1013-1019.

Hassan, A.A. 2017. Evaluation of some Hungarian maize hybrids classified by FAO maturity groups on the basis of maturity under Egyptian conditions. Egypt. J. Plant Breed. 21(5): 340-349.

Hassan, M.M.M. 1999. Effect of planting date on the response of maize hybrids to nitrogen fertilization. M.Sc. Thesis, Fac. Agric. Al-Azhar Univ., Egypt.

Jiban Shrestha; Mano; Kandel and Amit Chaudhary. 2018. Effect of planting time on growth, development and productivity of maize (Zea mays L.). J. Agric. Natural Resources 1(1): 43-50.

Khalifa, K.I. 2019. Morphology and environmental requirements. In: MAIZE (Field corn, sweet corn and popcorn). First ed. (In Arabic). Pp. 20-41.

Liaqat, W.; M.F. Jan and H. Ahamad. 2018. Sowing maize on optimum time in season is unaffordable for higher yield. Sci. Nat. Res., 8(5): 175-176.

Marakinyo, A.F.; A. Oluwaranti; B.A. Baffour; M. Abebe and A. Obafemi. 2011. Classification of maize into maturity groups. Maize program. IITA, IBADAN, Nigeria.

Marton, L.G.; D. Szieberth and Csuros. 2004. New method to determine FAO number of varieties.

Genetica, Vol. 36(1):83-92.

Monsanto Seed Co., 2015. Corn growth stages and GDU requirements. Agronomic Spotlight Bulletin.

Sarvari and Futo, 2000. Correlation between the planting date, yield and grain moisture content of maize hybrids in chernozem soil. Debrecene Egytem Agr artudomanyi ko zlemenyek J., 1:32-41.

SAS Institute, Inc. 2000. SAS/STAT User's Guide, Version 9.1 SAS Institute, Cary, NC, USA.

Shrestha, J.; M. Kandel and A. Chaudhary. 2018. Effect of planting date on growth, development and productivity of maize (Zea mays L.). J. Agric. And Natural Resources. 1(1): 43-50.

Steel, R.G.D. and J.H. Torrie. 1980. Principles and procedures of statistics: A biometrical approach. 2nd (ed.) Mc. Graw-Hill Book Co. New York, USA.

USDA, North Dakota Agic. Bulletin, USA. 2020. Corn Growing Degree Days (GDD).

Varma, V.S.; K.K. Durga and P. Neelima. 2014. Effect of sowing date on maize seed yield and quality. Review of Plant Studies. 1(2): 26-38.